UNCLASSIFIED

AD NUMBER

AD869282

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

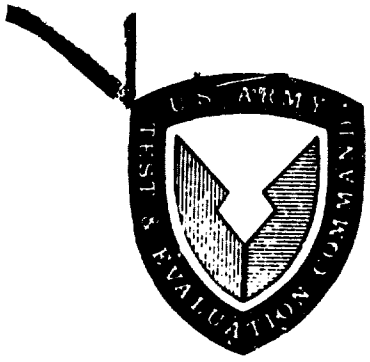
FROM

Distribution authorized to DoD only; Specific Authority; MAR 1970. Other requests shall be referred to Army Munitions Laboratory, Attn: SMUFA-J9100, Frankford Arsenal, PA 19137. Pre-dates formal DoD distribution statements. Treat as DoD only.

AUTHORITY

FA, d/a ltr, 14 Aug 1973

THIS PAGE IS UNCLASSIFIED



"FOR INFORMATION ONLY,
ACTION BY HIGHER AUTHORITY PENDING"

20

AD_____

RDTE PROJECT NO_____

USATECOM PROJECT NO 8-MU-002-000-003

USAIB PROJECT NO 3253

USACDC AC NO_____

USASASA PROJECT NO_____

AD NO. AD869282
DDC FILE COPY

PRODUCT IMPROVEMENT TEST OF

CARTRIDGES, 5.56-MM, ASSEMBLED WITH STEEL CARTRIDGE CASES

FINAL REPORT

By

CAPTAIN LARRY J. REGAN

SGT MICHAEL L. KUCZINSKI

MARCH 1970

DDC
RECEIVED
MAY 21 1970
C

UNITED STATES ARMY INFANTRY BOARD
Fort Benning, Georgia 31905

Best Available Copy

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005 Mr Crider/sr/3608

AMSTE-BC 7 MAY 70

SUBJECT: Product Improvement Test of Cartridge, 5.56mm, Assembled with Steel Cartridge Cases, USATECOM Project No. 8-MU-002-000-003

Commanding Officer
Frankford Arsenal
ATTN: SMUFA-J9100
Philadelphia, Pa 19137

1. Subject report published by US Army Infantry Board is forwarded for your information.

2. The position of this command will be forwarded upon review and analysis of reports from tests in progress at the US Army Arctic Test Center and the Aberdeen Proving Ground.

3. It is estimated that the position letter will be published on or before 29 January 71.

FOR THE COMMANDER:

1 Incl
subj report (5 cys)

GOODWIN MORROW
Acting Director
Inf Mat Test Dir

Copies furnished:
CG USAMC ATTN: AMCRD-WI (2 cys)
AMCMR-C (2 cys)
AMCRD-U (1 cy)
CG USCONARC ATTN: ATIT-RD-MD (4 cys)
CG USAWECOM ATTN: AMSWE-RDS (4 cys)
PM, Rifles, USAWECOM (5 cys)
USACDC LO, USATECOM (23 cys)
USMC LO, USATECOM (1 cy)
Pres, USAIB ATTN: STEBC-SA (w/o incl)
CO USASASA (1 cy)

Distribution

This document may be further distributed by any holder only with the specific prior approval of the Commanding Officer, Frankford Arsenal, Philadelphia, Pennsylvania 19137.

attn: SMUFA-J9100

Disposition Instructions

Destroy this report when it is no longer needed. Do not return it to the originator.

RDTE PROJECT NO

USATECOM PROJECT NO 8-MU-002-000-003

USAIB PROJECT NO 3253

USACDC AC NO

USASASA PROJECT NO

PRODUCT IMPROVEMENT TEST OF CARTRIDGES, 5.56-MM, ASSEMBLED WITH STEEL CARTRIDGE CASES

FINAL REPORT

By

CAPTAIN LARRY J. REGAN
SGT MICHAEL L. KUCZINSKI

MARCH 1970

UNITED STATES ARMY INFANTRY BOARD
Fort Benning, Georgia 31905

TABLE OF CONTENTS

ABSTRACT

This Product Improvement Test of Cartridge, 5.56-mm, Assembled with Steel Cartridge Cases, was conducted by the US Army Infantry Board at Fort Benning, Georgia, during the period 14 October 1969 through 11 February 1970. The daily temperatures during testing varied between 9° F. to 86° F. The purpose of the test was to determine suitability of the 5.56-mm steel-cased cartridges to replace standard brass-cased cartridges, and to determine the physical and technical characteristics of the 5.56-mm steel-cased cartridges.

Specific test phases to which the steel-cased cartridges were subjected were physical characteristics, safety, cartridge-weapon compatibility, adverse conditions (60-day open storage period), reliability, and human factors. The performance of the steel cartridge case was compared to that of the brass cartridge case in pertinent subtests.

There were no deficiencies found during the test. There was one shortcoming found: the susceptibility of the test cartridges to rust.

There were 47 incidents of split cases out of 21,642 steel-cased rounds fired, for a .22% rate of incidents during testing. However, these split cases did not adversely affect the operation of the weapons.

There were 71 malfunctions with weapons firing control cartridges and 53 malfunctions with weapons firing test cartridges. All malfunctions, with the exception of three, were either weapon- or magazine-caused. The three exceptions were cartridge-caused malfunctions. Two of the cartridge-caused malfunctions were with control cartridges, and one with test cartridges.

The blast, flash, noise, and felt recoil produced by the test cartridges were comparable to those of the control cartridges. The test cartridges ejected farther to the rear and right than did the control cartridges.

It was concluded that the steel-cased 5.56-mm cartridges are compatible with the M16A1 rifle and are suitable for US Army use under intermediate climatic conditions. It was recommended that the steel-cased 5.56-mm cartridges be subjected to more environmental service-type testing, specifically tropic, prior to their release for world-wide and unrestricted US Army use.

Best Available Copy

FOREWORD

The US Army Infantry Board was responsible for test planning, test execution, and test reporting.

SECTION 1. SUMMARY

1.1 BACKGROUND

For a number of years Frankford Arsenal has carried on a program to develop suitable steel cases as a substitute for brass cases for small arms ammunition. The use of steel cases would alleviate the effects of copper shortages which usually occur in wartime. From this program, Frankford Arsenal has developed both 7.62-mm and 5.56-mm steel cartridge cases, and has requested testing to evaluate the overall serviceability of the steel cases. The 7.62-mm steel-cased cartridges were tested by the US Army Infantry Board in 1968.

1.2 DESCRIPTION OF MATERIEL

1.2.1 The steel-cased 5.56-mm cartridges, ball and tracer, are identical to the standard 5.56-mm cartridges, Ball, M193 and Tracer, M196, except that the cartridge cases are made of heat-treated steel instead of copper alloy and have a baked phenolic varnish coating, which is OD in color.

1.2.2 Hereinafter, the steel-cased 5.56-mm cartridges, ball and tracer, will be referred to as the test cartridge(s) or test ammunition. The brass-cased 5.56-mm cartridges, ball and tracer, will be referred to as control cartridge(s) or control ammunition.

1.3 TEST OBJECTIVES

1.3.1 To determine the physical characteristics of the test cartridges.

1.3.2 To determine the suitability of steel-cased test cartridges to replace the control cartridges under temperate climatic conditions.

1.4 SCOPE

The Product Improvement Test of Cartridges, 5.56-mm, Assembled with Steel Cartridge Cases, was conducted by the United States Army Infantry Board (USAIB), at Fort Benning, Georgia, under prevailing intermediate climatic conditions, during the period 14 October 1969 to 11 February 1970. Ten test soldiers, representative of those who can be expected to use and maintain the cartridges in the field, were used in testing. The Brass Case 5.56-mm Cartridges, Ball, M193 and Tracer, M196, were used as control cartridges. Twenty rifles, 5.56-mm, M16A1, were used during the test. Ten of the rifles were manufactured by General Motors and 10 were manufactured by Colt's, Inc. Five of each model M16A1's were designated to fire the test cartridges and were referred to throughout testing as test weapons; 5 of each model M16A1's were designated to fire the control cartridges and were referred to throughout testing as control weapons. Except as noted, the test weapons fired only the test cartridges and the control weapons

fired only the control cartridges. The test soldiers handled, carried, and maintained the cartridges and weapons during certain periods of testing and fired the test and control cartridges throughout all periods of testing. Temperatures during testing varied between 9° F. and 86° F. The test and control cartridges were subjected to storage in light and heavy rainfall during 36 days of the test period. Samples of the test and control cartridges were exposed to open storage for a maximum period of 60 days. Except as noted, the firing of the test and control cartridges throughout testing was accomplished by firing half of the test and control cartridges in the semiautomatic mode and half of the test and control cartridges in the automatic mode.

The performance of the steel cartridge cases in this test was compared with that of the brass cartridge cases and with criteria developed by USAIB, since no specific criteria were provided.

1.5 SUMMARY OF RESULTS

1.5.1 There were no deficiencies found during testing. There was one shortcoming found, and that was the susceptibility of the test cartridge to rust.

1.5.2 The average weights of a 20-round sample size of the two types of test and control cartridges were:

a. Steel-cased ball - 168.6525 grains

b. Steel-cased tracer- 165.5225 grains

c. Brass-cased ball - 178.64 grains

d. Brass-cased tracer- 175.5525 grains

Although the difference in weight between the test and control cartridges (with ball and tracer) is statistically significant, the difference in weight had no significant effect on the function of the weapons.

1.5.3 The performance and reliability of the test cartridge during firing were comparable to the control cartridge.

1.5.4 During open-storage phases of testing, test cartridges showed a greater susceptibility to rust than did control cartridges.

1.5.5 There were 71 malfunctions with weapons firing control cartridges, from a total of 21,302 control cartridges fired, and 27 of those malfunctions were with control tracer cartridges. There were 53 malfunctions with weapons firing test cartridges, from a total of 21,642 test cartridges fired, and 13 of those malfunctions were with test tracer cartridges. All malfunctions, with the exception of three, were either weapon- or magazine-caused. The three exceptions were cartridge-caused. They were: one primer blowout with a steel-cased cartridge; one primer blowout with a control cartridge; and one incident of a cracked portion of the cartridge case bevel on a control cartridge.

1.5.6 The human factor characteristics of the test cartridge were comparable to the control cartridge in respect to noise, flash, blast, and felt recoil produced by the cartridge. The ejection pattern of test cartridges was farther to the rear and right of the firers' positions than the ejection pattern of the control cartridges. This ejection pattern did not adversely effect the firer (whether left-handed or right-handed) nor the adjacent firer.

1.6 DISCUSSION

The split cases, which occurred during testing, cannot be classified as a shortcoming since they did not adversely affect the operation of the weapons, i.e., no malfunctions could be attributed to the split cases. However, it is suggested that this matter of split cartridges be re-examined by more technically qualified personnel.

Additionally, although the susceptibility of the test cartridge to rust was classified as a shortcoming, the occurrence of rust resulted from exposure to only limited environmental conditions. During the time frame of this test there were no periods of extended exposure to combined high temperature and high humidity. It is felt, therefore, that the steel-cased cartridges should be tested under the span of environmental conditions, specifically, an environmental service-type test at the Tropic Test Center, to determine what effect exposure to that climate will have on the steel-cased cartridges. It is understood that an Arctic Test of the steel-cased cartridges will be conducted.

1.7 CONCLUSION

The US Army Infantry Board concludes that, based on the results of this test, the Cartridges, 5.56-mm, Assembled with Steel Cartridge Cases, are compatible with the M16A1 rifle and are suitable for US Army use under intermediate climatic conditions.

1.8 RECOMMENDATION

The US Army Infantry Board recommends that the Cartridges, 5.56-mm, Assembled with Steel Cartridge Cases, be subjected to more environmental service-type testing, specifically tropic, prior to their release for world-wide and unrestricted US Army use.

SECTION 2. DETAILS OF TEST

2.1 SUBTEST NO 1, PREOPERATIONAL INSPECTION AND PHYSICAL CHARACTERISTICS

2.1.1 Objectives

2.1.1.1 To insure that the test and control cartridges and associated weapons were in proper condition for testing.

2.1.1.2 To determine and compare the physical characteristics of the test and control cartridges.

2.1.2 Criteria

2.1.2.1 The test and control weapons and cartridges must be in proper condition for testing (item 1, app II).

2.1.2.2 The physical characteristics of the test ammunition shall be comparable to those of the control ammunition (item 2, app II).

2.1.3 Method

2.1.3.1 Test and control cartridges were checked for defects; any defects found were described and recorded. All weapons were given a technical inspection prior to beginning the test.

2.1.3.2 Each weapon was function fired with 60 rounds of each type test and control cartridges: 20 rounds semiautomatic fire; 20 rounds automatic fire in 2- to 3-round bursts; and 20 rounds automatic fire in one burst.

2.1.3.3 Lot numbers of all test and control cartridges were recorded. Twenty of each type test and control cartridges were randomly selected, weighed, and their major dimensions were measured. The weights and measurements were recorded and compared. These data were also compared to available technical data. Appropriate photographs were taken.

2.1.4 Results

2.1.4.1 All test and control cartridges and associated weapons were found to be in proper condition for test.

2.1.4.2 The following lot numbers and quantities of test and control cartridges were furnished for testing:

Test	Control
M193 Ball, LC-SP-844 (20,160 rds)	M193 Ball, LC-SP-845 (20,160 rds)
M196 Tracer, LC-SP-846 (5,040 rds)	M196 Tracer, LC-SP-847 (5,040 rds)

NOTE: Frankford Arsenal personnel stated that the ball test and control cartridges were loaded with the same propellant - WC-846, and that the tracer test and control cartridges were loaded with the same propellant - IMR-8208M.

2.1.4.3 The following serial numbers, makes, and numbers were assigned to the M16A1's utilized during testing:

General Motors				Colt			
Test		Control		Test		Control	
T1	3073854	C1	3073266	T1	1322510	C1	1326485
T2	3074663	C2	3075216	T2	1323056	C2	1327319
T3	3073273	C3	3074626	T3	1322984	C3	1326930
T4	3072621	C4	3074295	T4	1327271	C4	1323074
T5	3072887	C5	3070426	T5	1322618	C5	1323271

2.1.4.4 The average weights and measurements of the 20-round sample sizes of the two types of test and control cartridges are shown in Table 2-1. Detailed physical data on selected samples of test and control cartridges are contained in Chart 3-1, Appendix I.

TABLE 2-1

RECORD OF AVERAGE WEIGHTS AND MEASUREMENTS
OF TEST AND CONTROL CARTRIDGES (20-round sample size)

	Control (Average)		Test (Average)	
	Ball	Tracer	Ball	Tracer
Overall Length	2.2475 in.	2.2473 in.	2.2496 in.	2.2509 in.
Diameter-Case Neck	0.2489 in.	0.2490 in.	0.2484 in.	0.2496 in.
Case Base	0.3747 in.	0.3748 in.	0.3744 in.	0.3745 in.
Overall Weight	178.64 gr.	175.5525 gr.	168.6525 gr.	165.5225 gr.

2.1.4.5 Test cartridges, both ball and tracer, weighed less than the control cartridges, both ball and tracer (as shown in table 2-1).

2.1.4.6 The test cartridges had a baked phenolic varnish coating, OD in color; the control cartridges had a metal finish with no type of coating.

2.1.4.7 It required more force to extract projectiles from test cartridges than from control cartridges. Note: All test ball and tracer cartridges in the selected sample could not be completely disassembled to weigh and to measure the component parts. During function firing 14 malfunctions

occurred with the control cartridges and 3 malfunctions occurred with the test cartridges (ref Chart 3-2a, app I). In the opinion of the test officer, these malfunctions were caused by the test and control weapons being new and not broken-in.

2.1.4.8 A photograph of test and control cartridges is shown in Figure 1, Appendix I.

2.1.5 Analysis

2.1.5.1 The test and control cartridges and associated weapons meet the criteria listed in paragraph 2.1.2.1.

2.1.5.2 The physical characteristics of the test cartridges are comparable to those of the control cartridges.

2.2 SUBTEST NO 2, SAFETY

2.2.1 Objective

To determine whether the test cartridges are safe for Army use.

2.2.2 Criteria

Use of the test cartridges must require no additional safety precautions in regard to storage, handling, and firing beyond those required for control cartridges (item 3, app II).

2.2.3 Method

During the conduct of all testing, observations were made to determine any unsafe conditions of the test cartridges.

2.2.4 Result

Throughout testing, no safety hazards were noted in the use of the test cartridges.

2.2.5 Analysis

The test cartridges can be safely fired under temperate climatic conditions, provided normal safety precautions are followed.

2.3 SUBTEST NO 3, CARTRIDGE-WEAPON COMPATIBILITY

2.3.1 Objective

To determine whether the test cartridges are compatible with the M16A1 rifle.

2.3.2 Criteria

The test cartridges must be comparable to the control cartridges in respect to compatibility with the M16A1 rifle (item 4, app II).

2.3.3 Method

2.3.3.1 Throughout testing, observations were made and recorded on test and control cartridge-weapon performance. Firing and functioning data were analyzed for evidence of any incompatibility between the test and control cartridges and the weapons in which they were employed.

2.3.3.2 Particular note was made of the performance of the test cartridges as to loading (to include stripping from magazine and clips), feeding, extraction, ejection pattern, signature effects (day and night), weapon wear, case casualties, and other facets of cartridge-weapon functioning. A comparison was made between the test and control cartridges as to compatibility with the weapons.

2.3.3.3 A cyclic rate of fire exercise was conducted at the beginning and at the end of testing. Two test and 2 control weapons were utilized for the exercises. One hundred and eighty rounds of each type test and control ammunition were fired from each of the 2 test and 2 control weapons. Firing was done automatically in 20-round bursts. The cyclic rate of each 20-round burst was recorded by a visicorder.

2.3.4 Results

2.3.4.1 A record of weapon firing, functioning, and malfunctions throughout testing is shown in Chart 3-2; a record of malfunctions by subtests is shown in Chart 3-2a, Apperdix I. (See key to malfunctions, Chart 3-2b.)

2.3.4.2 There were no difficulties encountered in loading (to include stripping from magazine and clips), feeding, and extraction of the test cartridges thoughout testing.

2.3.4.3 The test cartridges ejected in an area approximately 2 feet farther to the rear and right of the firing position than did the control cartridges.

2.3.4.4 There was no discernible difference between the muzzle flash of a weapon firing test cartridges and a weapon firing control cartridges.

2.3.4.5 A record of bore wear is shown in Chart 3-2c, Appendix I. Control weapon GM C5 had a broken extractor after 4,001 rounds and again after 5,521 rounds. These were the only breakages experienced in the test. There were no broken parts experienced with weapons firing the test cartridges.

2.3.4.6 There were 47 occurrences of split cases with the test cartridges (out of 21,642 cartridges fired), but none with the control cartridges. Split case incidents by subtests are shown in Table 2-2. The majority of the splits were along the mouth of the cases. It was determined that either the splits were not visible to the naked eye or that the splits occurred during firing of the cartridges since none were discovered during the pre-firing inspections of the test cartridges. However, there were no malfunctions with the test weapons as a result of the split cases. The photograph in Figure 2, Appendix I, shows three types of splits that occurred with the test cartridges.

2.3.4.7 Results of the cyclic rate of fire exercise are shown in Chart 3-3, Appendix I. All of the firing rates were within the mean acceptance rate of 700 to 900 rounds per minute, even though there was a significant difference between test and control tracer rate in the cyclic rate of fire exercise fired at the end of the test.

2.3.5 Analysis

2.3.5.1 The test cartridges are comparable to the control cartridges in respect to compatibility with the M16A1 rifle.

2.3.5.2 There is no significant difference in bore wear of the test and control weapons.

2.3.5.3 Although there were 47 incidents of split test cartridge cases either in the mouth, neck, or shoulder, no adverse effect on the test cartridge-weapon performance could be attributed to the split cases. Note: Representatives from Frankford Arsenal stated that the defect was either present in the test cartridge when it was fabricated and could not be detected by the ammunition quality inspector, or the case split at the time of firing due to the relative inelasticity of the steel case.

Best Available Copy

TABLE 2-2

RECORD OF SPLIT CASES IN TEST CARTRIDGES

Subtest Number	Type of Exercise	Number of Split Cases
1	Function firing, total of 2,400 rounds fired.	5
4	2.4.3.2 Thirty-day open storage, total of 5,640 rounds fired	
	a. Box in open storage, 3,360 rounds fired.	6
	b. Six bandoleers open storage, 1,680 rounds fired.	4
	c. Clips, open storage, 200 rounds fired.	2
	d. Ten loaded magazines, open storage, 400 rounds fired.	2
4	2.4.3.5 Tactical Exercise, total of 1,890 rounds fired.	6
4	2.4.3.7 Transportability test, total of 3,345 rounds fired.	12
4	2.4.3.9 Sixty-day storage, total of 1,680 rounds fired.	3
5	2.5.3.2 Six-thousand-round-reliability exercise 4,165 rounds fired in this specific exercise.	7
	Balance of 1,835 rounds fired in previous sub-tests.	
	Miscellaneous firing, total of 2,522 rounds fired	0
	Total of 21,642 rounds fired	47

2.4 [illegible] ADVERSE CONDITIONS (TEMPERATE)

2.4.1 Objective

To determine and compare the performance of the test and control cartridges under adverse and temperate climatic conditions.

2.4.2 Criteria

The test cartridges' performance under adverse and temperate climatic conditions must be comparable to that of the control cartridges (item 5, app II).

2.4.3 Method

2.4.3.1 The test and control cartridges for each of the exercises listed in paragraph 2.4.3.2 were placed in a fenced-in open storage area. The area had no overhead cover and afforded no protection for the ammunition against climatic conditions. Throughout testing, note was made of the performance of the test and control cartridges after exposure to adverse and temperate climatic conditions encountered in other subtests. Data accumulated in other subtests bearing on performance under adverse conditions were recorded, analyzed, and compared in this subtest.

2.4.3.2 A sample of each type test and control cartridges was placed in open storage as specified below:

a. One box (overpack), 1,680 rounds, of each type test and control cartridge was exposed for a period of 30 days.

b. Six bandoleers, 140 rounds per bandoleer in seven 2-clip pockets, of each type test and control cartridge were placed in open storage. After 7 days of exposure, 3 bandoleers were removed from storage. The other 3 bandoleers were removed from open storage after 14 days of exposure.

c. Ten clips, 10 rounds per clip, of each type test and control cartridge were removed from bandoleers and placed in open storage for a period of 30 days. The cartridges and clips were examined every seventh day during the period.

d. Ten loaded magazines of each type test and control cartridge were placed in open storage for a period of 30 days, where they were exposed to natural rainfall at least once during the first week of storage. They were exposed to .88 inches of rain during the 30-day open storage period. During this period half of the magazines (5 with each type cartridge) were not handled. At the end of each 7 days of storage the other half of the magazines were unloaded, inspected, and reloaded. At the end of the 30-day period the cartridges were removed from all magazines.

Best Available Copy

2.4.3.3 Records were maintained during the open storage period relative to daily temperature extremes, humidity conditions, and precipitation occurring.

2.4.3.4 At the end of each period specified in paragraph 2.4.3.2 above, the cartridges were examined, the effects of exposure were noted (including photographs where appropriate), and, where deemed safe, the cartridges were fired. Weapons performance was observed and the results were analyzed and compared.

2.4.3.5 In a simulated tactical exercise, test and control cartridges, in tactical packaging (bandoleers) and in weapons, were subjected to fording operations, dragged through sand and mud, and exposed to wind-blown dust. After exposure to the conditions described, the cartridges and weapons were shaken and wiped off as is normally accomplished under combat conditions, and, where considered safe, were fired. Difficulties encountered and firing performance were recorded. A comparison was made between the performance of the test and control cartridge-weapon systems.

2.4.3.6 Three M16A1's were fired for 5 consecutive days, 200 rounds per weapon per day, of a 4-ball to 1-tracer load. One M16A1 was fired with test cartridges. One M16A1 was fired with control cartridges. The remaining M16A1 fired mixed test and control cartridges (1 for 1). The weapons were not cleaned during the 5 days of firing. A round was left chambered after each day's firing, except the last day. Weapons and cartridges were left in open storage but covered with a poncho, or similar covering, during this period. A record of firing performance and difficulties encountered was made. Results were compared between the performance of test and control cartridge-weapon systems.

2.4.3.7 One box and 10 loose bandoleers were transported in the bed of a military vehicle over rough terrain for a minimum distance of 20 miles. The ammunition was not restrained in the vehicle. At the end of this exercise the ammunition was dropped to the ground from the bed of the truck. The ammunition was then inspected, any damage resulting was noted, and, if judged safe, the ammunition was then fired in weapons. Results were recorded.

2.4.3.8 Ten bandoleers, 10 clips, and 10 loaded magazines of test and control cartridges each were thrown a minimum distance of 15 feet. Cartridges were then inspected, any damage resulting was noted, and, if judged safe, the rounds were fired in weapons. Results were recorded.

2.4.3.9 In another storage exercise test and control ammunition was subjected to open storage for a period of 60 days in the following manner: Five bandoleers, 8 magazines, and 12 clips each of test ball and control ball were stored in a bunker and in an open area. The ammunition was inspected at the end of every 7 days of storage. The magazines were unloaded, inspected, and reloaded every 7 days of storage.

Photographs were taken when deemed appropriate. At the end of 60 days the stored ammunition was inspected and, if deemed safe, fired. Results were recorded, analyzed, and compared.

2.4.3.10 Six 20-round magazines of test ball cartridges and six 20-round magazines of control ball cartridges in plastic protective bags (Bag, Protective, Cartridge, Magazine, Plastic) were placed in open storage for a period of 30 days. The magazines were removed from the plastic bags, rounds stripped from the magazines, inspected and then reloaded, every 2 weeks of open storage. At the end of the specified period of storage the magazines and cartridges were inspected, effects of exposure were noted, they were deemed safe to fire, and were fired.

2.4.4 Results

2.4.4.1 The open storage area is shown in Figure 3, Appendix I.

2.4.4.2 The results of inspection of the test and control cartridges after each [illegible] outlined in paragraph 2.4.3.2 were as follows:

a. Test and control cartridges from box (overpack) open storage were inspected after the 30-day open storage period. There were no rust spots or indications of any damage to the outward appearances of the cartridges. This was due to the protection afforded by the pack[illegible] in which the cartridges were packed. All cartridges were deemed safe to fire, and were fired. There were 2 malfunctions with weapons firing test cartridges and 2 malfunctions with weapons firing control cartridges (ref Chart 3-2a, app I).

b. After 7 days of open storage 3 bandoleers of each type test and control cartridges were visually inspected. There were no changes to the physical appearance of the control cartridges with the exception of a small [illegible] of varnish and dirt. In respect to the steel-cased cartridges, there was evidence of surface rust (oxidation) on some of the cartridges; however, the rust was removed by wiping the cartridges with cloth material. The remaining bandoleers of test and control cartridges were inspected after 14 days of storage. The control cartridges once again appeared varnished and the test cartridges had a slightly heavier coating of surface rust than those inspected on the seventh day of storage. A photograph of test cartridges stored in bandoleers for 14 days is shown in Figure 4, Appendix I. All of the test and control cartridges from bandoleer open storage (7 and 14 days) were inspected, were deemed safe to fire, and were fired. There were no difficulties or malfunctions during firing of the test and control cartridges from the 7-day storage. There were 4 malfunctions during the firing of the test and control cartridges from 14-day open storage; 2 of the malfunctions were with weapons firing control cartridges and 2 with a weapon firing test cartridges (ref Chart 3-2a, app I).

Best Available Copy

c. The cartridges and clips were inspected every 7 days of the 30-day open storage period. Surface rust formed on the test cartridges for the first 3 weeks, followed by a rust formation the fourth week that appeared to blister the phenolic varnish finish on the test cartridges. Control cartridges showed a gradual increase of tarnish from week to week of open storage. There was surface rust on the base of some of the control cartridges; this appeared as if it had originally formed on the metal clips holding the cartridges. Surface rust formed on all the metal clips holding both the test cartridges and the control cartridges. The test and control cartridges were inspected, were deemed safe to fire, and were fired. There was 1 malfunction with control cartridges, but no malfunctions with test cartridges (ref Chart 3-2a, app I).

d. Five magazines of each type cartridge were inspected after each 7 days of storage. During the inspection it was noted that the top 3 rounds of test cartridges loaded into the magazines were the only rounds that had a large amount of rust formation on them. However, rust formation in the form of rust spots gradually increased in size and corrosive action on all of the cartridges with each week of open storage. It was noted that the top 3 control cartridges in magazines gradually became more tarnished with each week of open storage. There were surface rust spots and rust spots in areas on the inside of the magazines. At the end of the open storage period the magazines were inspected, were deemed safe to fire, and were fired. There were no malfunctions with the weapons firing test cartridges and no malfunctions with weapons firing control cartridges (ref Chart 3-2a, app I).

2.4.4.3 A record of daily temperature extremes, humidity conditions, and rainfall during the open storage period is found in Chart 3-4, Appendix I.

2.4.4.4 After the simulated tactical exercise which included alternately submerging the test and control cartridges in water for 15 minutes, dragging them through dirt, and covering them with mud for 45 minutes, the test and control cartridges were placed in open storage for 36 hours. Upon inspection of the cartridges, they were deemed safe to fire and were fired. There was 1 malfunction with weapons firing test cartridges and 3 malfunctions with weapons firing control cartridges (ref Chart 3-2a, app I).

2.4.4.5 Three weapons were used for the 5-day consecutive firing exercise. On the fourth and fifth day of the exercise, the first round from each magazine had to be manually fed into the chamber of each of the 3 weapons by operating the charging handle. This was possibly due to carbon buildup on the bolt carrier group. At the end of the 5-day firing exercise the weapons were disassembled and inspected. The weapon firing the mixture of brass, 4-ball to 1-tracer, appeared to have more carbon buildup on the bolt carrier group than did the other 2 weapons. The weapon firing the steel 4-ball to 1-tracer mixture

appeared to have the least amount of carbon buildup. There were 20 malfunctions with the weapon firing test cartridges, 20 malfunctions with the weapon firing control cartridges, and 20 malfunctions with the weapon firing the mixture of test and control cartridges. These malfunctions were all failures to feed the first round of each magazine fired on the fourth and fifth days of the exercise. Note: Magazines were not left in weapons during the storage period of this exercise.

2.4.4.6 The test and control cartridges that had undergone the transportability exercise were inspected for damage. There was no damage noted to the test or control cartridges, they were deemed safe to fire, and were fired. There were 6 malfunctions with the weapons firing test cartridges and 2 malfunctions with the weapons firing control cartridges (ref Chart 3-2a, app I).

2.4.4.7 Test and control cartridges, in magazines, clips, and bandoleers, that were thrown a distance of 15 feet were inspected; no damages were noted, they were deemed safe to fire, and were fired. There were 3 malfunctions with weapons firing test cartridges and 4 malfunctions with weapons firing control cartridges (ref Chart 3-2a, app I).

2.4.4.8 For the first 30 days of the 60-day open storage, there were the same changes to the physical appearance of the test and control cartridges as had been experienced by test and control cartridges in the previous 30-day open storage exercise. Appearance of the test cartridges for the period of time was characterized by an increase in surface rust, a blistering effect to the varnish finish, and a transfer of rust from the metal clip to the base of the cartridges. The control cartridges' appearance during this time was characterized by an increase in tarnished appearance and of rust transfer from metal clip to the base of the cartridges. On the 37th day of open storage, during the inspection, it was noted that the top 3 rounds of test cartridges loaded in the magazines had a thicker coating of rust on them than other rounds in the magazines, and a thicker coating of rust on them than clips of test cartridges stored in bandoleers. The control cartridges showed a gradual increase in tarnish and rust transfer from metal clips. It was also noted that test and control cartridges stored in the bunker were less dirty and rusty than those stored on the ground and that test and control cartridges in magazines and bandoleers were cleaner with less rust and/or tarnish than those in clips. This was generally the case throughout all of the open-storage period. While inspecting the test and control cartridges during the last 3 weeks of the 60-day open storage period, it was noted that there was a gradual increase in the coat of rust on the test cartridges with rust appearing at the mouth of the cartridge where the projectile seats, along the case in various places, and at the base of the rounds. The control cartridges showed a gradual increase in the amount of tarnish during the last 3 weeks of open storage and an increase of surface rust at the base of the

cartridge due to rust formed on the metal clips. At the end of the 60-day storage period the test and control cartridges were deemed safe to fire. (Note: A gun mount and lanyard were used to fire 40 rounds of each type cartridge from open-storage area as a safety precaution.) Photographs shown in Figures 5 through 8, Appendix I, show effects of open storage on the test and control cartridges in bandoleers and clips that were placed on the ground or in the bunker. There were no malfunctions with weapons firing test cartridges from the bunker storage and 3 malfunctions with weapons firing test cartridges from ground storage. There were 3 malfunctions with weapons firing control cartridges from bunker storage and 1 malfunction from ground storage (ref Chart 3-2a, app I).

2.4.4.9 The test and control cartridges in 20-round magazines, which had been placed in open storage in plastic bags, had surface rust on them from the second week of open storage on. The plastic bags kept dirt and rain off the cartridges, but moisture condensed on the inside of the bags. No malfunctions occurred during the firing of the test and control cartridges that had been kept in plastic bags.

2.4.5 Analysis

2.4.5.1 The test cartridges have a greater susceptibility to rust than the control cartridges during 30- and 60-day open storage. This is a shortcoming. The rust formations on the base of both the test and control cartridges stored in clips is attributable to the rust that forms on the metal clip which holds the cartridges.

2.4.5.2 There is no significant difference in the performance of weapons firing test cartridges when compared with the control cartridges during testing.

2.4.5.3 The shipping cases (overpack) provide adequate protection against rust for both test and control cartridges.

2.4.5.4 While the plastic bags adequately protect the magazines from dirt and rainfall, condensation forms on the inside of the plastic bags causing surface rust to form on the test cartridges and tarnish on the control cartridges.

2.5 SUBTEST NO 5, RELIABILITY

2.5.1 Objective

To determine and compare the reliability of the test and control cartridges.

2.5.2 Criteria

The test cartridges must be comparable to the control cartridges with respect to reliability (item 6, app II).

2.5.3 Method

2.5.3.1 Data gathered in other subtests relative to the reliability of the test and control cartridges were recorded, analyzed, and compared in this subtest.

2.5.3.2 Additional firing with the test and control cartridges was done in this subtest to accumulate a minimum of 6,000 rounds on each of 2 M16A1 rifles, one using test cartridges, and one using control cartridges. Ball test and control cartridges were used in this firing. Firing was done at the maximum sustained rates prescribed in the applicable field and technical manuals (12-15 rounds per minute). Results were recorded, analyzed, and compared.

2.5.3.3 After completion of the above exercises, the weapons were given a technical inspection and note was made of any excessive wear or parts breakage attributable to the test cartridges.

2.5.4 Results

2.5.4.1 Two weapons, GM C-5 and Colt T-1, were selected to fire this exercise. Colt T-1 had fired 1,835 rounds to this point in testing and GM C-5 had fired 1,890 rounds. During reliability firing exercise, 4,165 rounds of test cartridges were fired through Colt T-1 and 4,110 rounds of control cartridges through GM C-5, for a total of 6,000 rounds fired through each weapon.

2.5.4.2 There were 9 malfunctions with the weapon firing control cartridges and 3 malfunctions with the weapon firing test cartridges (ref Chart 3-2a, app I).

2.5.4.3 There was one incident of primer blowout involving a steel-cased cartridge, one incident of primer blowout with a control cartridge, and one incident of a cracked portion of the cartridge case bevel on one control cartridge. The 3 incidents stated above constitute the only ammunition-caused malfunctions to occur during testing.

2.5.4.4 See Chart 3-2a, Appendix I, for the total number of malfunctions.

2.5.4.5 Technical inspections were given to the weapons prior to, and at the end of, testing. Prior to the start of test all weapons were found to be in serviceable order (none needed repair); at the end of testing, 4 of the weapons were in need of repairs. The defects found with the 4 weapons were: bent rear ramp of carrying handle near rear sights on 2 of the weapons; and loose rear sights on 2 of the weapons. These defects were attributable to rough handling and the normal field use of the test and control weapons.

2.5.5 Analysis

There is no significant difference in the reliability of the weapons firing either the test or control cartridges.

2.6 SUBTEST NO 6, HUMAN FACTORS

2.6.1 Objective

To determine and compare the test and control cartridges from the human factors standpoint.

2.6.2 Criteria

The human factors characteristics of the test cartridges must be comparable to those of the control cartridges (item 7, app II).

2.6.3 Method

Throughout testing, the effects of blast, recoil, noise, flash, ejection pattern, and similar effects produced by the test cartridges and control cartridges were noted, recorded, and compared.

2.6.4 Results

2.6.4.1 At the end of testing, 8 test soldiers were asked to compare the test and control cartridges as to effects of noise, blast, and recoil. All 8 stated that the effects were equal for both cartridges.

2.6.4.2 The results of the comparison between test and control cartridges in respect to flash and ejection pattern were:

a. There was no discernable difference between the muzzle flash of a weapon firing test cartridges and a weapon firing control cartridges.

b. The test cartridges ejected farther to the rear and right of the firing position than did the control cartridges. The ejection pattern did not adversely affect the firer, whether left-handed or right-handed (two of the test soldiers fired left-handed), nor adjacent firers.

2.6.5 Analysis

There is no significant difference in human factors characteristics between test cartridges and control cartridges.

SECTION 3. APPENDICES

APPENDIX I. TEST DATA

CHART 3-1

TABULATED PHYSICAL DATA

(Weights in grains, measurements in inches)

	Control			Test		
	Mean	Standard Deviation	Sample Size	Mean	Standard Deviation	Sample Size
		CARTRIDGE, 5.56-MM, BALL				
Length						
Overall	2.2475		20	2.2496		20
Projectile	0.7446		20	**		
Case	1.7526		30	**		
Diameter						
Projectile	0.2241		20	**		
Case Neck	0.2489		20	0.2484		20
Case Base	0.3747		20	0.3744		20
Weight						
Overall	*178.64	1.0087	20	*168.6525	0.8228	20
Powder	27.70	0.4926	20	**		
Projectile	54.8075	0.2472	20	**		
Case	96.1325	0.8425	20	**		
		CARTRIDGE, 5.56-MM TRACER				
Length						
Overall	2.2473		20	2.2509		20
Projectile	0.8835		20	**		
Case	1.7531		20	**		
Diameter						
Projectile	0.2242		20	**		
Case Neck	0.2490		20	0.2496		20
Case Base	0.3748		20	0.3745		20
Weight						
Overall	*175.5525	0.7385	20	*165.5225	2.429	20
Powder	25.7875	0.1406	20	**		
Projectile	53.625	0.1888	20	**		
Case	96.1425	0.6830	20	**		

* Significant to the 99.5 level.

** Denotes those component parts of the steel case cartridges, both ball and tracer, which were not weighed or measured because the cartridges could not be disassembled.

CHART 3-2

FIRING RECORD CHART (by weapon)

Colt C1

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	*Mode	Round No.	Prob Cause	No. Occ.
60	60	-	-	-	Subtest 1- 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week-None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d week-None	-	-	-	-
400	-	-	-	40	" "	-	-	-	-
460	-	-	60	-	Misc Fire-None	-	-	-	-
530	-	-	70	-	Subtest 4-2.4.4.2d None	-	-	-	-
560	-	-	-	30	"	-	-	-	-
660	-	-	100	-	Subtest 4-2.4.4.2a None	-	-	-	-
840	-	-	180	-	Subtest 4-2.4.4.5 None	-	-	-	-
880	-	-	-	40	"	-	-	-	-
1190	-	-	310	-	Subtest 4-2.4.4.7 None	-	-	-	-

*Mode specified only for firings during which malfunctions occurred.

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
1400	-	-	210	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1600	-	-	160	-	Subtest 4- 2.4.4.6 None	-	-	-	-
	-	-	-	40	"	-	-	-	-
1800	-	-	160	-	"	-	-	-	-
	-	-	-	40	"	-	-	-	-
2000	-	-	160	-	"	-	-	-	-
	-	-	-	40	"	-	-	-	-
2200	-	-	160	-	FBF	Semi	1st rd each mag	Dirty Wpn	10
	-	-	-	40	None	-	-	-	-
2400	-	-	160	-	FBF	Semi	1st rd each mag	Dirty Wpn	10
	-	-	-	40	None	-	-	-	-
2580	-	-	180	-	FF	Auto	2254	Mag	1
					DF	Auto	2417 & 2418	Mag	1
2720	-	-	140	-	None	-	-	-	-
					Colt C2				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	-	-	40	FF	Auto	234	Mag	1
550	-	-	150	-	Subtest 4-2.4.4.2a None	-	-	-	-
710	-	-	160	-	Subtest 4 - 2.4.4.5 None	-	-	-	-
810	-	-	-	100	"	-	-	-	-
830	-	-	-	20	Subtest 4-2.4.4.2a None	-	-	-	-
1330	-	-	500	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1490	-	-	160	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1530	40	-	-	-	Subtest 4- 2.4.4.9 None	-	-	-	-
1710	-	-	180	-	FTF	Auto	1266	Ammo	1
1870	-	-	160	-	None	-	-	-	-
					Colt C3				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d Week - FF	Semi	186	Mag	1
400	-	-	-	40	None	-	-	-	-
500	-	-	100	-	Subtest 4-2.4.4.2a FF	Auto	259	Mag	1
690	-	-	190	-	Subtest 4- 2.4.4.5 None	-	-	-	-
770	-	-	-	80	FF	Auto	490	Mag	1
800	-	-	-	30	Subtest 4-2.4.4.2a None	-	-	-	-
1080	-	-	280	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1290	-	-	210	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1450	-	-	160	-	Subtest 4- 2.4.4.9 None	-	-	-	-
1590	-	-	140	-	FF	Semi	1231	Mag	1
					Colt C4				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	FF	Auto	98	Mag	1

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	-	-	40	" "	-	-	-	-
740	-	-	340	-	Subtest 4- 2.4.4.5 None	-	-	-	-
850	-	-	110	-	Subtest 4- 2.4.4.7 None	-	-	-	-
960	-	-	110	-	Subtest 4- 2.4.4.8 None	-	-	-	-
					Colt C5				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	-	60	-	" "	-	-	-	-
180	-	-	-	60	FF	Semi	62,63,64, 65,66,67	Mag	6
240	-	60	-	-	BOB	Semi	64, 65	Mag	2
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	-	-	40	" "	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
500	-	-	100	-	Subtest 4-2.4.4.2c None	-	-	-	-
582	-	-	-	82	DF	Semi	342,343	Mag	1
622	-	-	-	40	Subtest 4-2.4.4.2a None	-	-	-	-
932	-	-	310	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1102	-	-	170	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1162	60	-	-	-	Cyclic Rate- None	-	-	-	-
1222	-	60	-	-	" "	-	-	-	-
1282	-	-	60	-	" "	-	-	-	-
1342	-	-	-	60	" "	-	-	-	-
					GM C1				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60		-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	-	-	40	" "	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
460	-	-	60	-	Subtest 4-2.4.4.2d None	-	-	-	-
500	-	-	-	40	None	-	-	-	-
600	-	-	100	-	Subtest 4-2.4.4.2a FF	Semi	346	Mag	1
660	-	-	-	60	None	-	-	-	-
820	-	-	160	-	Subtest 4- 2.4.4.5 None	-	-	-	-
920	-	-	-	100	DF	Auto	675, 676	Mag	1
1300	-	-	380	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1480	-	-	180	-	Subtest 4- 2.4.4.8 FF	Semi	1302	Mag	1
					GM C2				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	-	-	40	" "	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No. Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
430	-	-	30	-	Subtest 4-2.4.4.2d None	-	-	-	-
460	-	-	-	30	"	-	-	-	-
610	-	-	140	-	Subtest 4-2.4.4.2a None	-	-	-	-
770	-	-	160	-	Subtest 4- 2.4.4.5 None	-	-	-	-
870	-	-	-	100	"	-	-	-	-
1110	-	-	240	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1310	-	-	200	-	Subtest 4- 2.4.4.8 DF	Auto	981,982	Mag	1
					FBR	Auto	1150	Mag	1
1490	-	-	180	-	Subtest 4- 2.4.4.9 None	-	-	-	-
1650	-	-	160	-	"	-	-	-	-
					GM C3				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st weak - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-

Round Acc.	Steel Case B	T	Brass Case B	T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
360	-	-	40	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	-	-	40	" "	-	-	-	-
420	-	-	20	-	Subtest 4-2.4.4.2d None	-	-	-	-
460	-	-	-	40	"	-	-	-	-
650	-	-	190	-	Subtest 4-2.4.4.2a None	-	-	-	-
810	-	-	160	-	Subtest 4- 2.4.4.5 None	-	-	-	-
970	-	-	-	160	"	-	-	-	-
990	-	-	-	20	Subtest 4-2.4.4..2a None	-	-	-	-
1300	-	-	310	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1480	-	-	180	-	Subtest 4- 2.4.4.8 None	-	-	-	-
2480	250	250	250	250	Subtest 4- 2.4.4.6 FBF	Semi	1st rd last 20 mags	Dirty Wpn	20
(These 20 malfunctions occurred on 4th and 5th day--1st round each mag due to carboned weapon. First round was steel ball)									
2660	-	-	180	-	None	-	-	-	-
2840	-	-	180	-	"	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					GM C4				
60	60	-	-	-	Subtest 1 -2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	FF	Auto	4th	Mag	1
					FX	Auto	5th	Wpn	1
					BOB	Semi	16th	Mag	1
240	-	-	-	60	None	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st Week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d Week - None	-	-	-	-
400	-	-	-	40	" "	-	-	-	-
440	-	-	40	-	Subtest 4-2.4.4.2d None	-	-	-	-
540	-	-	-	100	Subtest 4-2.4.4.2a None	-	-	-	-
740	-	-	200	-	Subtest 4- 2.4.4.5 None	-	-	-	-
830	-	-	-	90	FF	Semi	583	Mag	1
880	-	-	-	50	Subtest 4-2.4.4.2a None	-	-	-	-
1110	-	-	230	-	Subtest 4- 2.4.4.7 DF	Auto	740,741	Mag	1
1270	-	-	160	-	Subtest 4- 2.4.4.8 FF	Auto	961	Mag	1

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					GM C5				
60	60	-	-	-	Subtest 1 - 2.1.4.7	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st Week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	-	40	-	Subtest 4-2.4.4.2b 2d Week - None	-	-	-	-
400	-	-	-	40	" "	-	-	-	-
460	60	-	-	-	Cyclic Rate - None	-	-	-	-
520	-	60	-	-	" "	-	-	-	-
580	-	-	60	-	" "	-	-	-	-
640	-	-	-	60	" "	-	-	-	-
690	-	-	50	-	Subtest 4-2.4.4.2d None	-	-	-	-
720	-	-	-	30	"	-	-	-	-
820	-	-	100	-	Subtest 4-2.4.4.2a None	-	-	-	-
990	-	-	170	-	Subtest 4- 2.4.4.5 None	-	-	-	-
1070	-	-	-	80	"	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
1110	-	-	-	40	Subtest 4-2.4.4.2a None	-	-	-	-
1450	-	-	340	-	Subtest 4- 2.4.4.7 DF	Semi	1022, 1023	Mag	1
1650	-	-	200	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1710	60	-	-	-	Cyclic Rate - None	-	-	-	-
1770	-	60	-	-	" "	-	-	-	-
1830	-	-	60	-	" "	-	-	-	-
1890	-	-	-	60	" "	-	-	-	-
2730	-	-	840	-	Subtest 5- 2.5.4.2				
					FF	Semi	1673	Mag	1
					FBR	Semi	1851, 1871	Mag	2
					FF	Semi	2100	Mag	1
4410	-	-	1680	-	FF	Semi	3233, 3234	Mag	2
					FX	Semi	3601	Wpn	1
6000	-	-	1590	-	DF	Semi	5169	Mag	1
					FX	Semi	5171	Wpn	1

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					Colt T1				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	-	60	-	" "	-	-	-	-
180	-	-	-	60	FF	Semi	62,63, 64,65	Mag	4
240	-	60	-	-	FF	Semi	62	Mag	1
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	40	-	-	" "	-	-	-	-
460	60	-	-	-	Cyclic Rate - None	-	-	-	-
520	-	60	-	-	" "	-	-	-	-
580	-	-	60	-	" "	-	-	-	-
640	-	-	-	60	" "	-	-	-	-
700	60	-	-	-	Subtest 4-2.4.4.2d None	-	-	-	-
730	-	30	-	-	"	-	-	-	-
850	120	-	-	-	Subtest 4-2.4.4.2a None	-	-	-	-
980	130	-	-	-	Subtest 4- 2.4.4.5 None	-	-	-	-
1040	-	60	-	-	"	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
1455	415	-	-	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1635	180	-	-	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1835	200	-	-	-	Misc Firing- None	-	-	-	-
2675	840	-	-	-	Subtest 5- 2.5.4.2 DF	Semi	1810, 1811	Mag	1
4355	1680	-	-	-	FTF	Semi	3245	Ammo	1
6000	1645	-	-	-	DF	Auto	4570, 4571	Mag	1
					Colt T2				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4 .2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	40	-	-	" "	-	-	-	-
420	20	-	-	-	Subtest 4-2.4.4.2d None	-	-	-	-

Round Acc.	Steel B	Steel T	Brass B	Brass T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
520	100	-	-	-	Subtest 4-2.4.4.2a None	-	-	-	-
700	180	-	-	-	Subtest 4- 2.4.4.5 None	-	-	-	-
790	-	90	-	-	"	-	-	-	-
990	310	-	-	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1300	130	-	-	-	"	-	-	-	-
1430	130	-	-	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1630	160	-	-	-	Subtest 4- 2.4.4.6 None	-	-	-	-
	-	40	-	-	"	-	-	-	-
1830	140	-	-	-	"	-	-	-	-
		40	-	-	"	-	-	-	-
2030	160	-	-	-	"	-	-	-	-
		40	-	-	"	-	-	-	-
2230	160	-	-	-	FBF	Semi	1st rd each mag	Dirty wpn	10
		40	-	-	None	-	-	-	-
2430	160	-	-	-	FBF	Semi	1st rd each mag	Dirty wpn	10
		40	-	-	None	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob. Cause	Corr.
					Colt T3				
60	60	-	-	-	Subtest 1 - 2.1...7 None	-	-		
120	-	60	-	-	" "	-	-		
180	-	-	60	-	" "	-	-		
240	-	-	-	60	" "	-	-		
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-		
280	-	20	-	-	" "	-			
300	-	-	20	-	" "	-	-		
320	-	-	-	20	" "	-	-		
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-			
400	-	40	-	-	" "	-	-		
490	-	90	-	-	Subtest 4-2.4.4.2d None	-	-	-	-
520	30	-	-	-	"	-			
620	100	-	-	-	Subtest 4-2.4.4.2a None	-			
740	120	-	-	-	Subtest 4- 2.4.4.5 None	-			
830	-	90	-	-	"	-			
970	-	140	-	-	Subtest 4-2.4.4.2a None	-	-		
1260	290	-	-	-	Subtest 4- 2.4.4.7 DF	Auto	[illegible] 1081		
1500	240	-	-	-	Subtest 4- 2.4.4.8 BOB	Auto	[illegible]		

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					Colt T4				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	40	-	-	" "	-	-	-	-
460	60	-	-	-	Cyclic Rate - None	-	-	-	-
520	-	60	-	-	" "	-	-	-	-
580	-	-	60	-	" "	-	-	-	-
640	-	-	-	60	" "	-	-	-	-
760	120	-	-	-	Subtest 4-2.4.4.2a None	-	-	-	-
1030	270	-	-	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1210	180	-	-	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1270	60	-	-	-	Cyclic Rate - None	-	-	-	-
1330	-	60	-	-	" "	-	-	-	-
1390	-	-	60	-	" "	-	-	-	-
1450	-	-	-	60	" "	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					Colt T5				
60	60	-	-	-	Subtest 1 -2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-	-		
400	-	40	-	-	" "	-	-	-	
520	120	-	-	-	Subtest 4-2.4.4.2c None	-	-	-	-
602	-	82	-	-	"	-	-	-	-
732	-	130	-	-	Subtest 4- 2.4.4.2A None	-	-	-	-
1112	380	-	-	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1302	190	-	-	-	Subtest 4- 2.4.4.8 None	-	-		

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					GM T1				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	40	-	-	" "	-	-	-	-
460	60	-	-	-	Misc - None	-	-	-	-
500	40	-	-	-	Subtest 4-2.4.4.2d None	-	-	-	-
560	60	-	-	-	Subtest 4-2.4.4.2a None	-	-	-	-
740	180	-	-	-	Subtest 4- 2.4.4.5 None	-	-	-	-
820	-	80	-	-	"	-	-	-	-
1290	470	-	-	-	Subtest 4- 2.4.4.7 DP	Auto	751,752, 908, 909	Mag	2
1410	120	-	-	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1770	360	-	-	-	Subtest 4- 2.4.4.9 FP	Auto	1625	Mag	1

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					GM T2				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240		-	-	60	" "	-	-	-	
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	
300	-	-	20	-	" "	-	-	-	
320	-	-	-	20	" "	-	-	-	-
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-	-		
400	-	40	-	-	" "	-			
440	-	40	-	-	Subtest 4-2.4.4.2d None	-			
540	100	-	-	-	Subtest 4-2.4.4.2a None	-			
720	180	-	-	-	Subtest 4- 2.4.4.5 None	-			
780	-	60	-	-	"	-			
880	-	100	-	-	Subtest 4-2.4.4.2a None		-		
1140	260	-	-	-	Subtest 4- 2.4.4.1 DF	Semi	[illegible]	[illegible]	
1310	170	-	-	-	Subtest 4- 2.4.4.6 None	-			
1490	180	-	-	-	Subtest 4- 2.4.4.9 None	-			
1650	160	-	-	-	FF	Semi	[illegible]	[illegible]	

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					GM T3				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	40	-	-	" "	-	-	-	-
460	60	-	-	-	Subtest 4-2.4.4.2d None	-	-	-	-
590	130	-	-	-	Subtest 4-2.4.4.2a None	-	-	-	-
670	80	-	-	-	Subtest 4- 2.4.4.5 None	-	-	-	-
750	-	80	-	-	FF	Semi	510	Mag	1
870	-	120	-	-	Subtest 4-2.4.4.2a None	-	-	-	-
1220	350	-	-	-	Subtest 4- 2.4.4.7 DF		874	Mag	1
1370	150	-	-	-	Subtest 4- 2.4.4.8 FF	Semi	1064, 1065	Mag	2
1530	160	-	-	-	Subtest 4- 2.4.4.9 None	-	-	-	-
1690	160	-	-	-	"	-	-	-	-

Round Acc.	Steel Case B	T	Brass Case B	T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					GM T4				
60	60	-	-	-	Subtest 1 -2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4.2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	-	40	-	-	Subtest 4-2.4.4.2b 2d week - FF	Auto	174, 175	Mag	2
400	40	-	-	-	None	-	-	-	-
460	60	-	-	-	Subtest 4-2.4.4.2d None	-	-	-	-
560	100	-	-	-	Subtest 4-2.4.4.2a DF	Semi	301, 302	Mag	1
730	170	-	-	-	Subtest 4- 2.4.4.5 None	-	-	-	-
880	-	150	-	-	"	-	-	-	-
1000	-	120	-	-	Subtest 4-2.4.4.2a None	-	-	-	-
1210	210	-	-	-	Subtest 4- 2.4.4.7 None	-	-	-	-
1340	130	-	-	-	Subtest 4- 2.4.4.8 None	-	-	-	-
1520	180	-	-	-	Subtest 4- 2.4.4.9 None	-	-	-	-
1660	140	-	-	-	FF	Auto	1376	Mag	1

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
					GM T5				
60	60	-	-	-	Subtest 1 - 2.1.4.7 None	-	-	-	-
120	-	60	-	-	" "	-	-	-	-
180	-	-	60	-	" "	-	-	-	-
240	-	-	-	60	" "	-	-	-	-
260	20	-	-	-	Subtest 4-2.4.4 .2b 1st week - None	-	-	-	-
280	-	20	-	-	" "	-	-	-	-
300	-	-	20	-	" "	-	-	-	-
320	-	-	-	20	" "	-	-	-	-
360	40	-	-	-	Subtest 4-2.4.4.2b 2d week - None	-	-	-	-
400	-	40	-	-	" "	-	-	-	-
430	30	-	-	-	Subtest 4-2.4.4.2d None	-	-	-	-
460	-	30	-	-	"	-	-	-	-
580	120	-	-	-	Subtest 4-2.4.4.2a FF	Semi	301	Mcg	1
760	180	-	-	-	Subtest 4- 2.4.4.5 None	-	-	-	-
820	-	60	-	-	"	-	-	-	-
950	130	-	-	-	Subtest 4-2.4.4.2a None	-	-	-	-
1210	260	-	-	-	Subtest 4- 2.4.4.7 DF	Semi	1483, 1484	Mag	1
1370	160	-	-	-	Subtest 4- 2.4.4.8 None	-	-	-	-

Round Acc.	Steel Case B	Steel Case T	Brass Case B	Brass Case T	Subtest No & Type of Malfunction	Mode	Round No.	Prob Cause	No. Occ.
1430	60	-	-	-	Cyclic Rate - None	-	-	-	-
1490	-	60	-	-	" "	-	-	-	-
1550	-	-	60	-	" "	-	-	-	-
1610	-	-	-	60	" "	-	-	-	-
1790	180	-	-	-	Subtest 4- 2.4.4.9 None	-	-	-	-
1950	160	-	-	-	"	-	-	-	-

CHART 3-2a

MALFUNCTIONS BY SUBTEST, WEAPON, AND TYPE

(See Chart 3-2b for abbreviations for malfunctions)

Applicable Subtest	Weapon	Type and No. Malf.	Type Cartridge	Round Number
ST 1, Preoperational Inspection, para 2.1.4.7	Colt T-1	1 FF	Steel Case	62
		4 FF	Brass Case	62,63,64,65
	Colt C-4	1 FF	Brass Case	98
	Colt C-5	6 FF	Brass Case	62-67
		2 BOB	Steel Case	64,65
	GM C-4	1 FF	Brass Case	4
		1 FX	Brass Case	5
		1 BOB	Brass Case	16
ST 4, Adverse Conditions, para 2.4.4.2a	Colt C-3	1 FF	Brass Case	259
	GM T-4	1 DF	Steel Case	301,302
	GM T-5	1 FF	Steel Case	301
	GM C-1	1 FF	Brass Case	346
2.4.4.2b	Colt C-2	1 FF	Brass Case	234
	Colt C-3	1 FF	Brass Case	186
	GM T-4	2 FF	Steel Case	174,175
2.4.4.2c	Colt C-5	1 DF	Brass Case	242,243
2.4.4.2d		None		
2.4.4.4	Colt C-3	1 FF	Brass Case	490
	GM T-3	1 FF	Steel Case	510
	GM C-1	1 DF	Brass Case	675,676
	GM C-4	1 FF	Brass Case	583
2.4.4.5	Colt T-2	10 FF	Steel Case	2031,2051,2071,2091, 2111,2131,2151,2171, 2191,2211
		10 FF	Steel Case	2231,2251,2271,2291, 2311,2331,2351,2371, 2391,2411
	Colt C-1	10 FF	Brass Case	2001,2021,2041,2061, 2081,2101,2121,2141, 2161,2181
		10 FF	Brass Case	2201,2221,2241,2261, 2281,2301,2321,2341, 2361,2381
	GM C-3	5 FF	Steel Case	1481,1501,1521, 1541,1561
		5 FF	Steel Case	1581,1601,1621, 1642,1661
		5 FF	Brass Case	1681,1701,1721, 1741,1761

Applicable Subtest	Weapon	No. Malf.	Type Cartridge	Round Number
ST 4, con't		5 FF	Brass Case	1781,1801,1821, 1841,1861
2.4.4.6	GM T-1	2 DF	Steel Case	751,752 - 908,909
	Colt T-3	1 DF	Steel Case	1083,1084
	GM T2	1 DF	Steel Case	629,630
	GM T-3	1 DF	Steel Case	874,875
	GM T-5	1 DF	Steel Case	1483,1484
	GM C-4	1 DF	Brass Case	740,741
	GM C-5	1 DF	Brass Case	1022,1023
2.4.4.7	Colt T-3	1 BOB	Steel Case	1313
	GM T-3	2 FF	Steel Case	1064,1065
	GM C-1	1 FF	Brass Case	1302
	GM C-2	1 DF	Brass Case	981,982
		1 FBR	Brass Case	1150
	GM C-4	1 FF	Brass Case	961
2.4.4.8	Colt C-1	1 FF	Brass Case	2254
		1 DF	Brass Case	2417,2418
	Colt C-2	1 FTF	Brass Case	1266
	Colt C-3	1 FF	Brass Case	1231
	GM T-1	1 FF	Steel Case	1625
	GM T-2	1 FF	Steel Case	1472
	GM T-4	1 FF	Steel Case	1376
ST 5, Reliability, para 2.5.4.2	Colt T-1	2 DF	Steel Case	1810,1811 - 4570,4571
		1 FTF	Steel Case	3245
	GM C-5	1 FF	Brass Case	1673
		2 FBR	Brass Case	1851, 1871
		1 FF	Brass Case	2100
		2 FF	Brass Case	3234,3244
		1 FX	Brass Case	3601
		1 DF	Brass Case	5169
		1 FX	Brass Case	5171

NOTE: Total Malfunctions: Steel Case - 53
Brass Case - 71

Best Available Copy

CHART 3-2b

KEY TO MALFUNCTION CHART FOR 3-2 AND 3-2a

FF	-	Failure to feed
FF sr	-	Failure to feed, snubbed round
FFR	-	Failure to fire
FX	-	Failure to extract
FJ	-	Failure to eject
FJ sb	-	Failure to eject, spin back
FBC	-	Failure of bolt to close
SR*	-	Short recoil
IFR	-	Inadvertent firing
FMR	-	Failure to maintain cyclic rate
BUB *	-	Bolt underrode base of round in feeding
DF	-	Double feed, two rounds fed from magazine at once
BCE *	-	Bolt catch engaged bolt carrier instead of bolt after firing the last round in the magazine
BFE *	-	Bolt failed to engage base of round in magazine
BLE *	-	Bolt lacked sufficient energy to force round from magazine
BOB *	-	Bolt overrode base of round in feeding from magazine
FBF	-	Failure of bolt to go forward
FBR	-	Failure of bolt to remain at rear after last round
FCB	-	Failure on closure of bolt
FJC	-	Failure to eject clip
FML **	-	Failure of the magazine to lock in rifle
FTR	-	Failure of trigger to return to forward position
F2R	-	Fired 2 rounds on one rearward movement of trigger
BCS	-	Bolt catch stopped forward movement of bolt before last round of magazine was fired
FS	-	Failure to strip round
FSO	-	Failure of bolt to sear off
FFO *	-	Failure to feed round over to stripping position
FBS	-	Failure of bolt to sear
FRA	-	Failure to remain in assembly
FL *	-	Failure to load by hand charging
PS *	-	Partial strip of round from link

* Most frequently description of the cause of malfunction, rather than a malfunction itself. For example, a failure to feed due to the bolt overriding the base of a round in feeding from a magazine would be abbreviated as FF (BOB).

** Cause of FF on some occasions.

CHART 3-2c

RECORD OF BORE MEASUREMENTS OF RIFLES AT MUZZLE AND BREECH END

(Measurements indicated in .0001 of an inch)

Rifle GM	Rifle Colt	Rds Fired	Muzzle Pre-Test	Muzzle Post-Test	Muzzle Wear	Breech Pre-Test	Breech Post-Test	Breech Wear
C-1		1480	.2209	.2209	.0000	.2209	.2214	.0005
C-2		1650	.2209	.2210	.0001	.2209	.2222	.0013
C-3		2840	.2208	.2208	.0000	.2208	.2216	.0008
C-4		1270	.2208	.2206*		.2208	.2216	.0008
C-5		6000	.2208	.2208	.0000	.2208	.2204	.0008
	C-1	2720	.2207	.2209	.0002	.2207	.2214	.0007
	C-2	1870	.2208	.2209	.0001	.2208	.2220	.0012
	C-3	1590	.2209	.2210	.0001	.2209	.2212	.0003
	C-4	960	.2207	.2206*		.2207	.2218	.0011
	C-5	1342	.2208	.2208	.0000	.2208	.2216	.0008
T-1		1770	.2209	.2212	.0003	.2209	.2214	.0005
T-2		1650	.2207	.2207	.0000	.2207	.2210	.0003
T-3		1690	.2208	.2208	.0000	.2208	.2210	.0002
T-4		1660	.2209	.2212	.0003	.2209	.2218	.0009
T-5		1950	.2209	.2212	.0003	.2209	.2214	.0005
	T-1	6000	.2207	.2210	.0003	.2207	.2100*	
	T-2	2430	.2209	.2214	.0005	.2209	.2222	.0013
	T-3	1500	.2209	.2206*		.2209	.2212	.0003
	T-4	1450	.2207	.2210	.0003	.2207	.2230	.0021
	T-5	1302	.2208	.2206*		.2208	.2218	.0010

Note: Asterisk denotes those post-test measurements that were less than pre-test measurements. This was due to particle buildup in lands and grooves of weapon which prevented an accurate measurement, therefore no measurement of wear could be recorded.

CHART 3-3

CYCLIC RATE EXERCISES

Weapon	Trial*	Rounds Per Minute			
		Test Ball	Control Ball	Test Tracer	Control Tracer
Pre-Test					
Colt C-3	1	800	750	787	706
	2	873	814	829	727
	3	857	787	800	706
Colt T-1	1	750	706	750	667
	2	857	857	857	800
	3	923	923	877	877
GM T-4	1	800	706	750	705
	2	857	857	857	800
	3	923	923	857	857
GM C-3	1	941	960	950	906
	2	1000	1000	1000	960
	3	970	980	980	991
Mean		879	855	858	884
Post-Test					
Colt C-5	1	800	750	800	750
	2	923.1	750	800	750
	3	774.2	888.9	888.9	857.1
Colt T-4	1	857.1	**	750	705.9
	2	857.1	857.1	857.1	827.6
	3	960	923.1	923.1	827.6
GM C-5	1	857.1	800	827.6	800
	2	960	857.1	827.6	800
	3	960	923.1	888.9	857.1
GM T-4	1	800	**	727.3	666.7
	2	827.6	827.6	857.1	800
	3	923.1	923.1	888.9	827
Mean		875	850	836	789

* Each trial - 20-round magazine.
** Unable to record results of this 20-round trial

CHART 3-4

OPEN STORAGE CLIMATIC DATA

Date	Temperature High	Temperature Low	Average Humidity	Rain (inches)
10-20-69	86	69	78%	.16
10-21-69	80	66	85	0
10-22-69	80	50	65	0
10-23-69	70	48	47	0
10-24-69	65	47	49	0
10-25-69	73	56	72	0
10-26-69	79	55	72	0
10-27-69	81	52	72	0
10-28-69	74	51	63	0
10-29-69	67	50	47	0
10-30-69	69	47	54	.10
10-31-69	74	56	74	.14
11-1-69	72	63	83	0
11-2-69	72	47	73	0
11-3-69	68	39	69	0
11-4-69	61	36	64	0
11-5-69	61	32	63	0
11-6-69	70	31	61	0
11-7-69	76	41	61	0
11-8-69	75	41	61	0
11-9-69	75	34	63	0
11-10-69	73	35	63	0
11-11-69	78	34	62	0
11-12-69	73	43	68	.05
11-13-69	51	37	80	.09
11-14-69	48	27	64	0
11-15-69	48	18	58	0
11-16-69	65	24	56	0
11-17-69	73	30	69	0
11-18-69	76	48	67	0
11-19-69	68	35	73	.34
11-20-69	59	27	52	0
11-21-69	63	29	61	0
11-22-69	69	28	58	0
11-23-69	70	38	73	0
11-24-69	75	45	68	0
11-25-69	70	49	74	.07
11-26-69	63	47	87	0
11-27-69	66	44	76	0
11-28-69	68	46	60	0
11-29-69	61	33	58	0
11-30-69	58	27	51	0

Date	Temperature High	Low	Average Humidity	Rain (inches)
12-1-69	65	33	58%	0
12-2-69	61	32	46	0
12-3-69	66	29	52	0
12-4-69	54	30	45	0
12-5-69	53	27	46	.01
12-6-69	54	41	68	.20
12-7-69	60	50	79	.86
12-8-69	48	35	74	0
12-9-69	50	30	78	T
12-10-69	51	45	84	.61
12-11-69	63	42	67	0
12-12-69	55	30	61	0
12-13-69	61	25	59	0
12-14-69	68	34	57	0
12-15-69	62	29	58	0
12-16-69	56	28	56	0
12-17-69	61	24	57	0
12-18-69	62	26	56	0
12-19-69	62	39	67	T
12-20-69	55	28	49	0
12-21-69	50	31	84	1.23
12-22-69	43	38	65	0
12-23-69	54	28	78	T
12-24-69	55	28	63	0
12-25-69	51	30	87	1.26
12-26-69	53	30	55	T
12-27-69	58	26	52	0
12-28-69	71	29	60	0
12-29-69	73	41	66	0
12-30-69	76	48	74	.54
12-31-69	47	41	71	.61
1-1-70	44	29	70	.07
1-2-70	34	21	57	0
1-3-70	44	30	62	0
1-4-70	53	22	50	0
1-5-70	52	27	53	.16
1-6-70	44	35	75	1.37
1-7-70	35	18	63	0
1-8-70	34	14	53	0
1-9-70	33	9	50	0
1-10-70	43	14	50	0
1-11-70	41	29	70	.34
1-12-70	49	39	72	.08

Date	Temperature High	Temperature Low	Average Humidity	Rain (inches)
1-13-70	58	27	48%	0
1-14-70	64	23	45	0
1-15-70	57	41	64	.11
1-16-70	60	40	55	.02
1-17-70	57	50	75	.23
1-18-70	61	4[illegible]	71	0
1-19-70	51	40	71	T
1-20-70	44	34	66	0
1-21-70	43	26	32	0
1-22-70	49	26	31	0
1-23-70	42	30	78	.17
1-24-70	62	31	55	0
1-25-70	66	31	74	.01
1-26-70	76	42	51	.03
1-27-70	72	35	60	0
1-28-70	73	36	73	0
1-29-70	72	47	80	1.04
1-30-70	49	32	47	0
1-31-70	58	22	53	0
2-1-70	56	28	69	.62
2-2-70	69	48	66	.51
2-3-70	51	20	69	.20
2-4-70	48	14	46	0
2-5-70	56	23	49	0
2-6-70	62	28	45	0
2-7-70	71	29	30	0
2-8-70	66	30	61	.02
2-9-70	53	38	55	.05
2-10-70	56	36	37	0

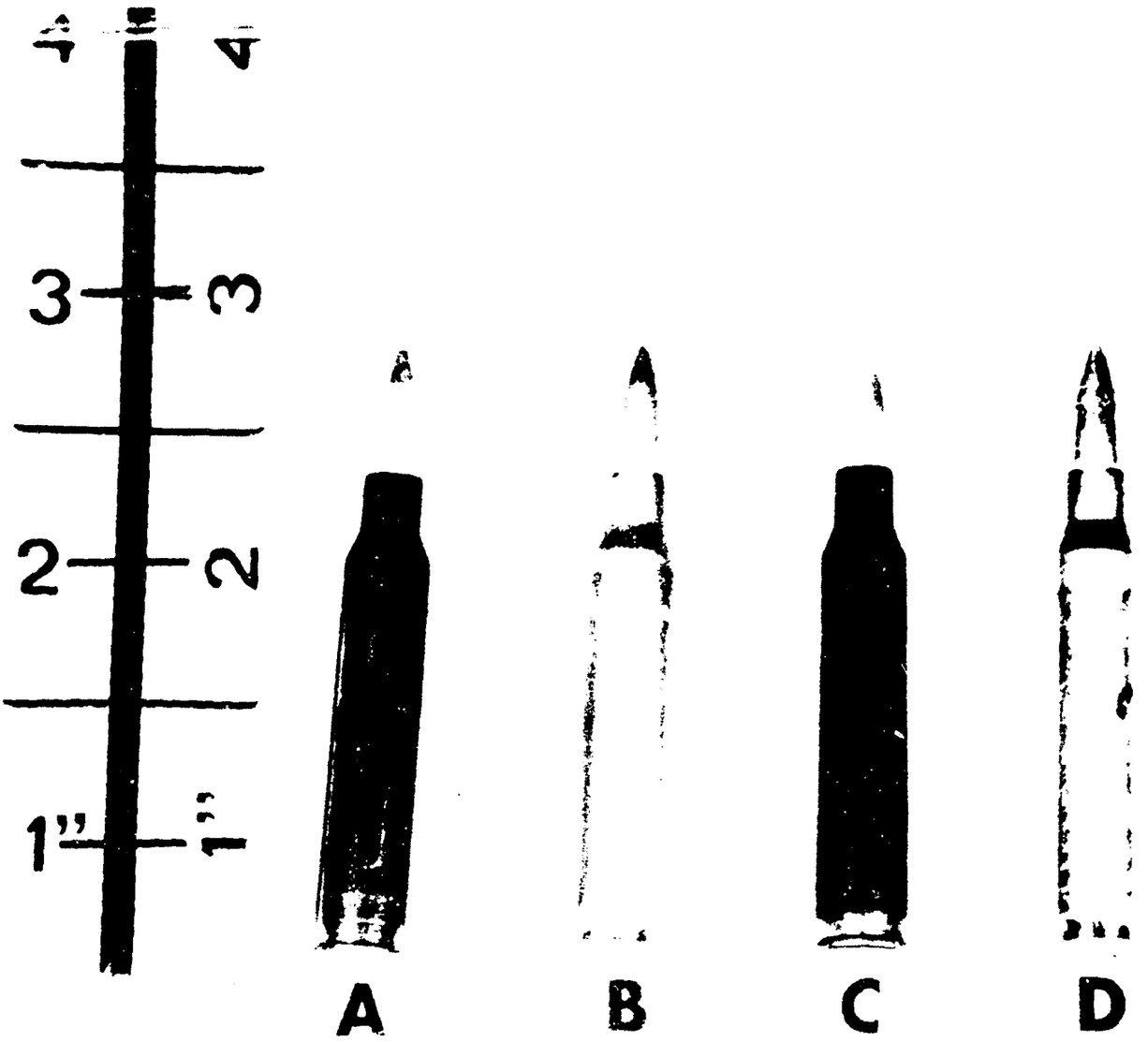


Figure 1

A - Cartridge, 5.56-mm, Ball, M193, Steel Cased

B - Cartridge, 5.56-mm, Ball, M193

C - Cartridge, 5.56-mm, Tracer, M196, Steel Cased

D - Cartridge, 5.56-mm, Tracer, M196

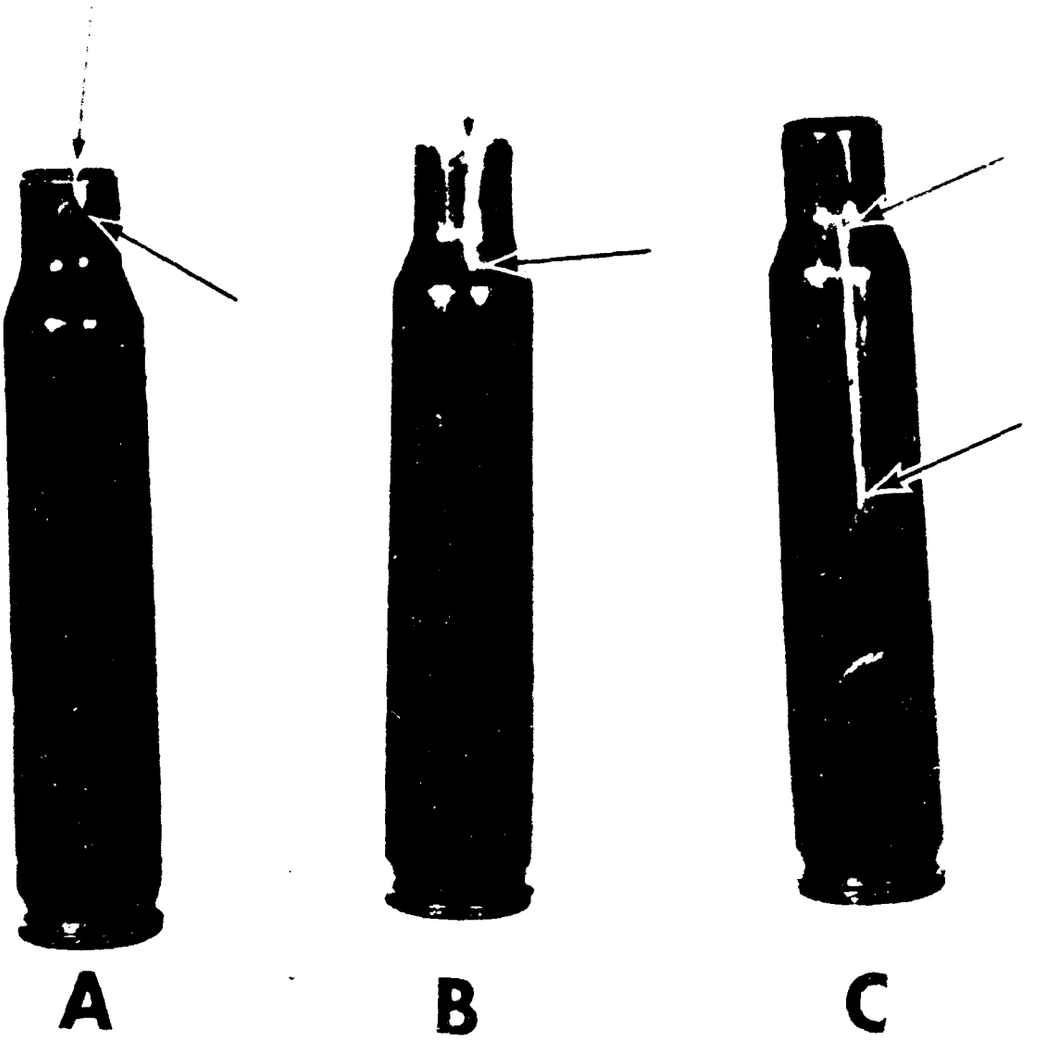


Figure 2

Cartridge Case Casualties for Cartridge, 5.56-mm, Steel Cased

A - Arrows indicate splits in mouth.

B - Arrows indicate splits in neck and shoulder region.

C - Arrows indicate splits in shoulder and case region.

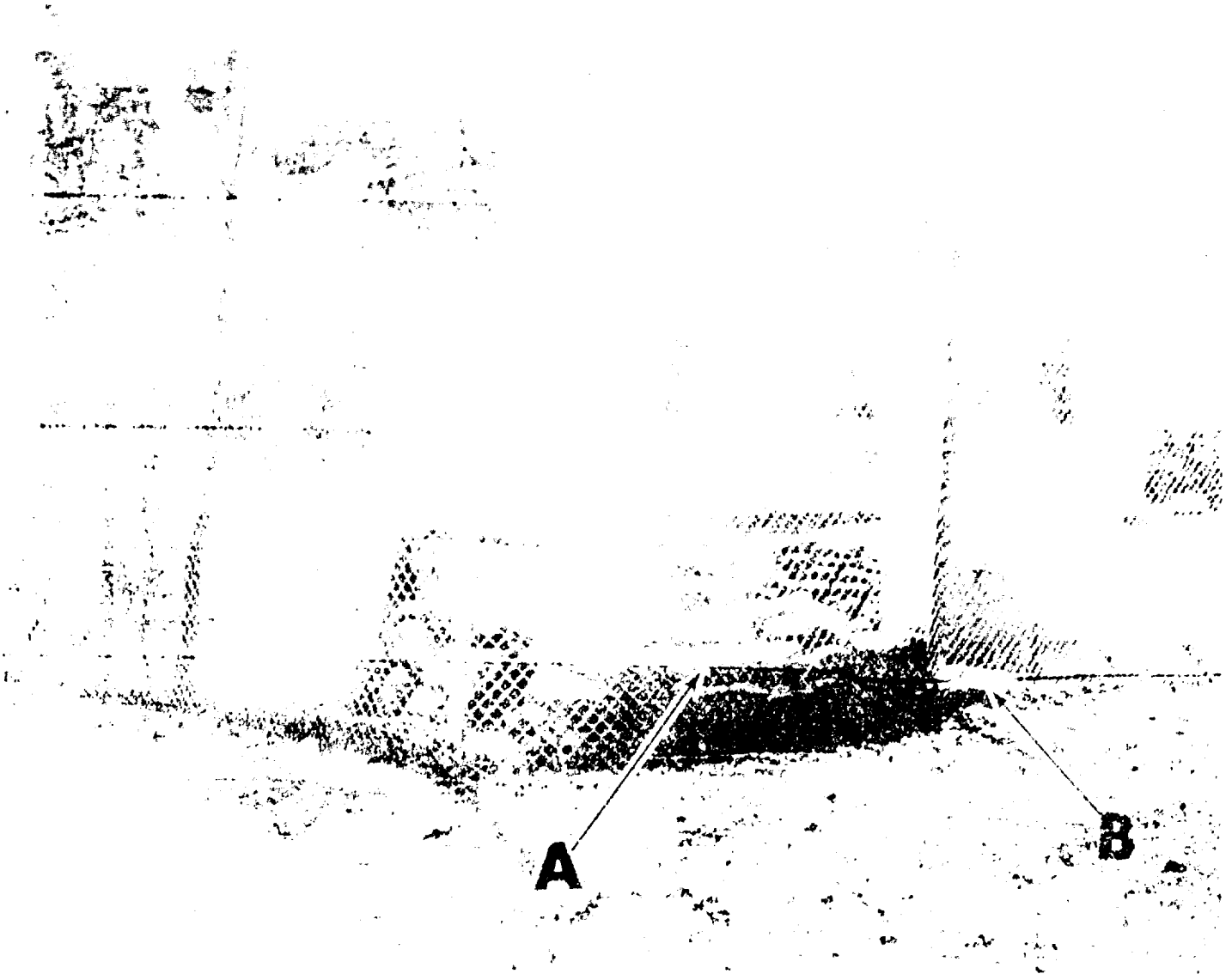


Figure 3

View of Open Storage Area

A - Tactical bunker used during 60-day open storage.

B - Area used for ground storage during the 30-day open storage period and the 60-day open storage period.

Best Available Copy

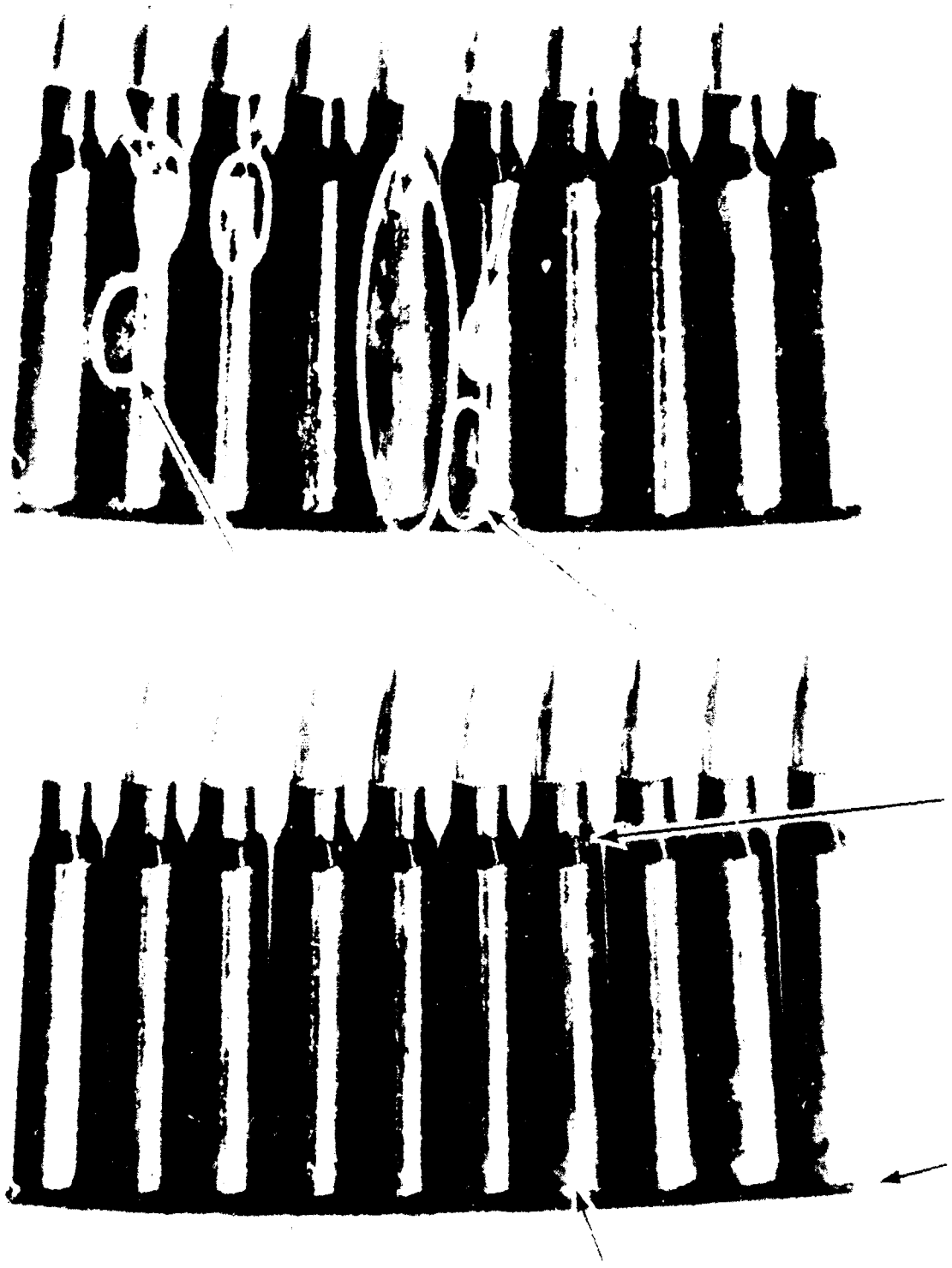
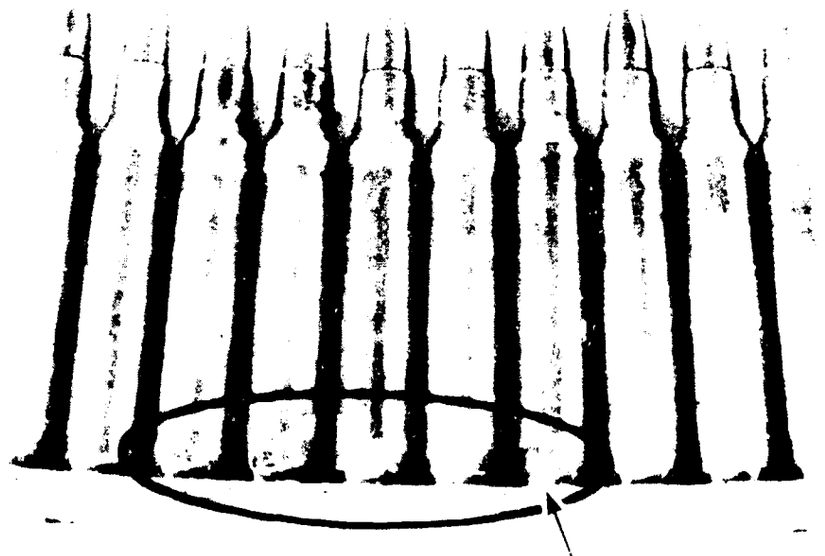


Figure 4

Test Cartridges, 5.56-mm, Ball, M193, from open storage, after 14 days storage in bandoleers. Arrows and circles show points or areas of rust on the cartridges.

1



2

Figure 5

Cartridges, 5.56-mm, Ball, M193, from Open Storage

1. Test cartridges stored in bandoleers on the ground 40 days. The two arrows to the left of the circle indicate grass and dirt particles. The circle indicates rust area.

2. Control cartridges stored in bandoleers on the ground 40 days. The arrow and circle indicate area where rust transfer from the clip to the base of the rounds occurred.

1

2

Figure 6

Cartridges, 5.56-mm, Ball, M193, from Open Storage

1. Test cartridges stored in clips on the ground 30 days. Arrows indicate dirt and sand particles on the cartridges.

2. Control cartridges stored in clips on the ground 30 days. Arrows indicate dirt and sand particles on the cartridges.

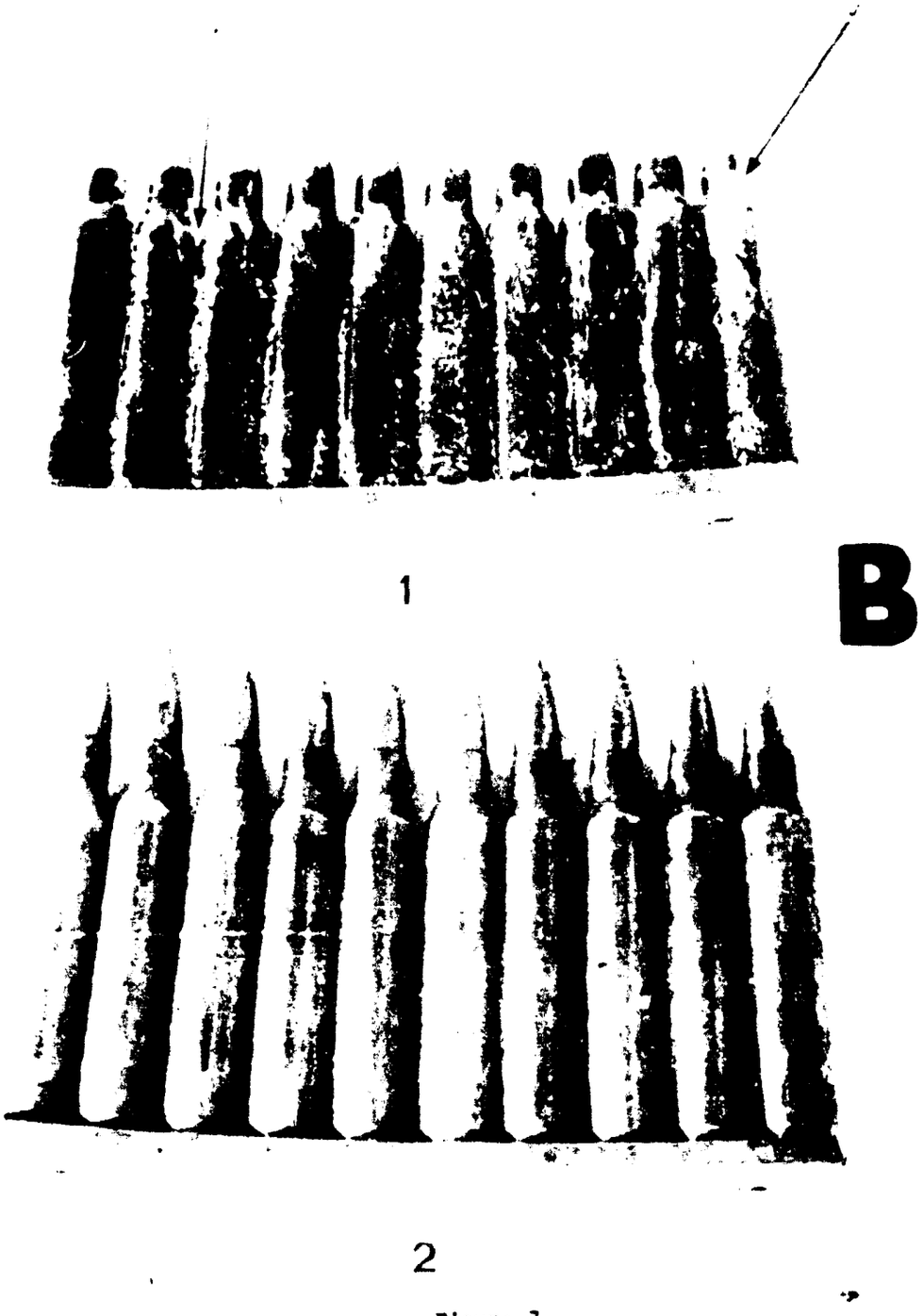


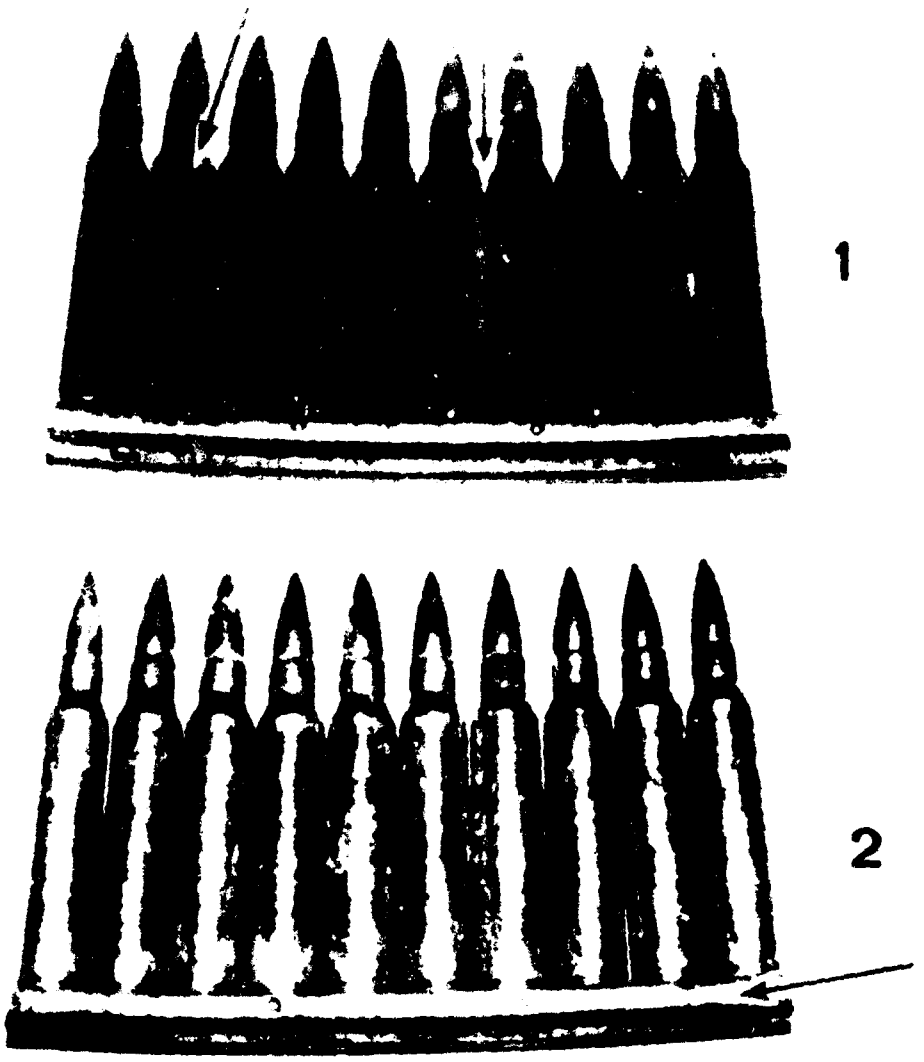
Figure 7

Cartridges, 5.56-mm, M193, Ball, from Open Storage

B denotes that test and control cartridges were stored in tactical bunker.

1. Test cartridges from clips stored in tactical bunker for 40 days. Arrows indicate mud and sand particles on the cartridges.

2. Control cartridges from clips stored in tactical bunker for 40 days.



1

2

B

Figure 8

Cartridges, 5.56-mm, Ball, M193, from Open Storage

B denotes that test and control cartridges were stored in a tactical bunker during open storage period.

1. Test cartridges from clip, tactical bunker storage, after 60 days. Arrows indicate dirt and rust on cartridges.

2. Control cartridges from clip, tactical bunker storage, after 60 days. Arrow indicates rust formation on metal clip.

APPENDIX II. TEST CRITERIA

Item	Source	Requirements	Applicable Subtest	Remarks
1	USAIB	The test and control weapons and cartridges must be in proper condition for testing.	2.1	Met. See Results, para 2.1.4 and Analysis, para 2.1.5.
2	USAIB	The physical characteristics of the test ammunition shall be comparable to those of the control ammunition.	2.1	Met, with the exceptions listed in Results, para 2.1.4.
3	USAIB	Use of the test cartridges must require no additional safety precautions in regard to storage, handling, and firing beyond those required for control cartridges.	2.2	Met. See Analysis, para 2.2.5.
4	USAIB	The test cartridges must be comparable to the control cartridges in respect to compatibility with the M16A1 rifle.	2.3	Met. See Analysis, para 2.3.5.
5	USAIB	The test cartridges performance under adverse and temperate climatic conditions must be comparable to that of the control cartridges.	2.4	Met. See Analysis, para 2.4.5.
6	USAIB	The test cartridges must be comparable to the control cartridges with respect to reliability.	2.5	Met. See Analysis, para 2.5.5.
7	USAIB	The human factors characteristics of the test cartridges must be comparable to those of the control cartridges.	2.6	Met. See Analysis, para 2.6.5.

APPENDIX III. DEFICIENCIES AND SHORTCOMINGS

1. DEFICIENCIES

None

2. SHORTCOMINGS

Shortcoming	Suggested Corrective Action	Remarks
Susceptibility of the steel-cased cartridges to rust.	Improved protective coating.	Subtest No 4.

APPENDIX IV. ABBREVIATIONS

App - appendix

Auto - automatic

C - control

F - Fahrenheit

Fig - figure

FM - field manual

GM - General Motors, Inc

GR - grain

IMR - improved rifle powder

In - inch

Inc - incorporated

LC - SP - Lake City - Special

Mag - magazine

M16A1 - rifle, 5.56-mm, M16A1

M193 - cartridge, 5.56-mm,ball, M193

M196 - cartridge, 5.56-mm, tracer, M196

MM - millimeter

No - Number

Occ - occurrences

OD - olive drab

Para - paragraph

Prob - probable

Ref - reference

APPENDIX V. REFERENCES

1. MIL-STD-636, Visual Inspection Standards for Small Arms Ammunition Through Caliber .50, dated 5 June 1958.

2. FM 23-9, Rifle, 5.56-mm, XM16E1, dated July 1966.

3. Letter, AMSTE-BC, HQ USATECOM, 11 June 1968, subject: "Test Directive for Product Improvement Tests of Cartridges, 5.56-mm, Assembled with Steel Cartridge Cases, USATECOM, Project No 8-8-0212-01, 02, 03."

4. APG Plan of Test for Product Improvement Test of Cartridge, 5.56-mm, Assembled with Steel Cartridge Cases, USATECOM Project No 8-8-0212-01, October 1968, with change 1, dated 6 December 1968.

5. Proposed Pamphlet on Definitions and Identifications of Malfunctions for 5.56-mm Weapons, dated 18 Dec 1968.

6. USAIB Final Report of Product Improvement Test of Steel Cases for 7.62-mm Cartridges, USATECOM Project No 8-7-0004-02, dated December 1968.

7. Letter, AMSTE-BC, HQ USATECOM, 20 Mar 69, subject: "Approval of Test Plans for Product Improvement Test of Cartridge, 5.56-mm, Assembled with Steel Cartridge Cases, USATECOM Project Nos 8-8-0212-01, 02."

8. TM 9-1005-249-12, Rifle, 5.56-mm, M16A1, with change (1005007309421) dated 2 Aug 1968, with change 1, dated 27 June 1969 and change 2, dated 12 September 1969.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author)	2a REPORT SECURITY CLASSIFICATION
United States Army Infantry Board Fort Benning, Georgia 31905	UNCLASSIFIED 2b GROUP

3 REPORT TITLE

Product Improvement Test of 5.56-mm Cartridges Assembled with Steel Cartridge Cases

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report. 14 October 1969 through 11 February 1970.

5 AUTHOR(S) (Last name, first name, initial)

Regan, Larry J, Captain
Kuczinski, Michael L. SGT E5

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1970	74	8

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	USATECOM Project No 8-MU-002-000-003
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	USAIB Project No 3253

10. AVAILABILITY/LIMITATION NOTICES

Destroy this report when it is no longer needed. Do not return it to the originator.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Commanding Officer, Frankford Arsenal, ATTN: SMUFA-J9100, Philadelphia, Pa 19137

13 ABSTRACT

This Product Improvement Test of Cartridge, 5.56-mm, Assembled with Steel Cartridge Cases, was conducted by the US Army Infantry Board at Fort Benning, Georgia, during the period 14 October 1969 through 11 February 1970. The daily temperatures during testing varied between 9° F. to 86° F. The purpose of the test was to determine suitability of the 5.56-mm steel-cased cartridges to replace standard brass cartridge cases, and to determine the physical and technical characteristics of the 5.56-mm steel-cased cartridges.

Specific test phases to which the steel-cased cartridges were subjected were physical characteristics, safety, cartridge-weapon compatibility, adverse conditions (60-day open storage period), reliability and human factors. The performance of the steel cartridge case was compared to that of the brass cartridge case in pertinent subtests.

There were no deficiencies found during the test. There was one shortcoming found: the susceptibility of the test cartridges to rust.

There were 47 incidents of split cases out of 21,642 steel-cased rounds fired for a .22% rate of incidents during testing. However, these split cases did not adversely affect the operation of the weapons.

There were 71 malfunctions with weapons firing control cartridges and 53 malfunctions with weapons firing test cartridges. All malfunctions, with the exception of 3, were either weapon- or magazine-caused. The 3 exceptions were cartridge-caused malfunctions. Two of the cartridge-caused malfunctions were with control cartridges, and one with test cartridge.

The blast, flash, noise, and felt recoil produced by the test cartridges were

DD FORM 1 JAN 64 1473

UNCLASSIFIED

Security Classification

DD Form 1473, Item 13, continued.

comparable to those of the control cartridges. The test cartridges ejected farther to the rear and right than did the control cartridges.

It was concluded that the steel-cased 5.56-mm cartridges are compatible with the M16A1 rifle and are suitable for US Army use under intermediate climatic conditions. It was recommended that the steel-cased 5.56-mm cartridges be subjected to more environmental service-type testing, specifically tropic, prior to their release for world-wide and unrestricted US Army use.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Cartridge, 5.56-mm, M193, Ball, Assembled with Steel Case						
Cartridge, 5.56-mm, M196, Tracer, Assembled with Steel Case						
Cartridge, 5.56-mm, M193, Ball						
Cartridge, 5.56-mm, M196, Tracer						
Steel-cased Ammunition						
5.56-mm Steel-Cased Ammunition						
M16A1 Rifle						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2*a*. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2*b*. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7*a*. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7*b*. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8*a*. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8*b*, 8*c*, & 8*d*. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9*a*. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9*b*. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, *or (U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

Best Available Copy